Effects of the Red Bench Fire on Coleopteran Communities, the Third year

FINAL REPORT FOR GRANT #INT-89430-GR with
MONTANA STATE UNIVERSITY
FS Contact: Gene Amman
Co-op Contact: Michael A. Ivie

SEMI-ANNUAL REPORT OF PROGRESS

# Effects of the Red Bench Fire on Coleopteran Communities, the Third Year.

23 March 1992

PIs: Michael A. Ivie and LaDonna L. Ivie

Our efforts continue to build data on the effects of the 1988 Red Bench Fire on beetle communities, while at the same time building data for base-line biodiversity studies of the Glacier National Park region.

The 1991 season progressed very well. Mr. Kelly Miller served as the on-site technician for the field season, with assistance from both PIs and several volunteers. The 24 permanent sites were reestablished in May, with a total installation of 210 traps. Sampling was done on a 1-week/3-week schedule, with 8 sampling periods. In a departure from previous years, all sampling periods will be counted, a three-fold increase in data generation. Technical help in the lab has been supplemented by 3 part-time seasonals. This high quality help has greatly improved our timeliness, and reduced our backlog. It has also allowed exploration of recapturing data that was not expected to be used from years 1 and 2.

Of the 1680 trap units data processing is 100% complete. Data collection (sorting) is also 100% complete for this material. Data capture (counting) is 30% complete at this time. Because there is 4 times as much material as in previous years, when only 1 of 4 weeks was counted, this actually represents a faster degree of progress than in previous years. Completion of data capture is expected by May 15, 1992. Data entry has not yet begun with the exception of updates to species lists and previous year data.

Data from year 2 (1990) is ready for analysis, with 100% completion of data capture and entry. In addition to the 1-week data collected for 1990, 3-week samples which were expected to be discarded have been returned to data status for lindgren funnels, have been fully retrieved, and data entry is complete. Three-week samples for the other trap types, which were pooled by site and trap type in the field have data collection complete for 85% of the total. Statistical methods for reconstituting these data are being investigated.

Data from year 1 (1989) is ready for analysis, with 100% completion of data capture and entry.

In addition to the 489 species of beetles of 63 families used in our analyses so far, there are a large number of species of Staphylinidae which had not been dealt with. Dr. J. S. Ashe of University of Kansas was brought in to sort this material, identify as much as possible, and teach co-PI L.Ivie to recognize the species. This 1 week activity added 135 species of beetles to the Park list, and made them available for databasing. Another difficult family of very similar-looking species, the Scolytidae, was the subject of a private training session for co-PI L.Ivie, kindly hosted by Malcolm Furniss of the University of Idaho. This has greatly increased our ability to effectively deal with this difficult but important group. Combining our established project database with the new staphylinid data and the other material referred to below, we now have well over 700 species of beetles documented from GNP.

Data from the Keating pit-fall study consisted of 360 samples. Data processing and collection is 100% complete, with capture (carabids only) expected to be complete by 15 April.

The experimental biodiversity sampling resulted in thousands of individual specimens. The hand collected material is 100% sorted, and approx. 1,500 specimens mounted and labeled from this material. Approximately 5% is currently identified and added to the data base. This will be continued on a time-available basis over the next 6 months. Similarly, the 10,000 specimens from ultra-violet light trap at West Glacier has proven this technique appropriate to the GNP environment. It had been expected that the night time temperatures were too low for lighting to be worth the effort. By correlating with the New Moon (for a dark sky), we ran the experiment for 7 days either side of that event for 3 months. The material was quite diverse, and well worth the effort. The material is 100% sorted, and a first pass at a synoptic collection has been mounted. This material is now being labeled. Identification and databasing will follow.

Our findings are giving great strength to the idea that Glacier National Park is a biodiversity hot-spot, with a fauna representative of vast areas on all sides, but not duplicated by any of those areas. Species reach their eastern, western, northern and southern limits in the North Fork area, resulting in a diverse and highly valuable biotic assemblage. Exciting finds this year included an undescribed genus and species of Endomycidae, the highest generic diversity ever documented at a single site for the Holarctic family Cryptophagidae (all but one of the 9 genera known from North America, the exception known only from south Florida), half of the Nearctic species of the boreal moss-feeding genus _Byrrhus_, and fully 1/4 of all species of that family (Byrrhidae) known from the continent. Glacier is the first place in North America to be known to host 3/4 of the species of _Dictyoptera_ (Lycidae).

Consider that this documentation is limited to a small area on the West side of the Park, and I believe it is obvious that GNP is an excellent representative of the boreal fauna of North America.

Other activities, peripheral to the funded study, but never-the-less resulting from it include a list of the Odonata of the Park (25+ spp., by Kelly Miller), a list of spiders taken in our study plots (51 spp., by J. H. Redner, Canadian National Insect Collection), and a list of the Psuedoscorpions taken in our study (7 spp., by Wm. Muchmore, University of Rochester). Salamander data are also being collected, and data from small mammal captures are being turned over to Keating for analysis. We have continued to pull all Hymenoptera from trap samples, in the hopes of eventually obtaining the funds to capture this rich data source.

Synoptic collections for the GNP museum are under development. The material is being loaded directly into Park equipment, so as to make the transfer as easy as possible. These collections will be a tremendous improvement in the in-Park facilities.

Attached are some examples of preliminary data analyses run on the first 2 years of data. These are not for release, but are instructive as to the power and possible usefulness of the final analyses.

SEMI-ANNUAL REPORT OF PROGRESS

# Effects of the Red Bench Fire on Coleopteran Communities, the Fourth Year.

01 February 1993

PIs: Michael A. Ivie and LaDonna L. Ivie
Montana State University
Bozeman, MT 59717

NPS Cooperative Agreement # CA 1268-1-9017
NPS Work Order # MSU - 3
NPS Project # GLAC-R91-0180

Report Period: 20 May 1992 - 01 February 1993

Our efforts continue to build data on the effects of the 1988 Red Bench Fire on beetle communities, while at the same time building data for base-line biodiversity studies of the Glacier National Park region. During this year, the study has begun to attract considerable attention. A list of news stories appearing in State and Regional press is appended. In addition, 3 presentations of methodologies and preliminary findings were made to local and national audiences:

Presentation 23 April 1992, Alton Jones Conference Center, Rhode Island, to NPS Working Group on Invertebrate Surveys, including National Program Staff of NPS.

Presentation 18 May 1992 in West Glacier to Management, Research and Interpretation staff.

Ivie, M. A., L. L. Ivie, and D. L. Gustafson. **Flight Intercepts and Lindgren Funnels vs. Pitfall Traps as Quantitative Devices for Coleopteran Biodiversity Measurement.** Poster presentation at National Meetings of the Entomological Society of America, Baltimore, 09 December 1992.

The 1992 season progressed very well. Biometrician Daniel Gustafson, who has assisted the project in previous years on a volunteer basis, joined the project staff this year. Dr. D. R. Mercer served as the on-site technician for the field season, with assistance from both PIs and several volunteers. The 24 permanent sites were reestablished in May, with a total installation of 226 traps. The increase over 1991 (210) was due to the change from one Lindgren funnel per site to 2 in forest habitats. This was due to data from years 1-3 indicating that the quality of data from that trap-type warranted an increased

level of effort. In addition to the 24 permanent sites, one each flight intercept and Lindgren funnel were placed in a meadow, to establish the effectiveness or lack there-of of these trap methods in that habitat.

Sampling was done on a 1-week/3-week schedule, with 9 sampling periods between 19 May and 17 September, an increase of one sampling period over 1991. Hourly technical help in the lab was done by Mr. Kelly Miller, who has worked on the project in various roles for 3 years, and Ms Niki Jefferies. This high quality help has greatly improved our timeliness, and reduced our backlog.

Of the 2043 trap units collected in 1992, 5 one-week sample periods and 4 3-week sample periods were accomplished. Data processing and collection (sorting) is 100% complete for the one-week samples, with data capture (counting) 40% complete for that sample type. Data collection (sorting) for the 3-week samples is 55%, and data capture (counting) 40% complete at this time. Completion of data capture for both sample types is expected by 15 May 1992. Data entry for 1992 has not yet begun with the exception of updates to species lists.

All backlog of one week samples for years 1989 thru 1991 was eliminated, and the data entered into the database during the first 6 months of PY1992. Thus, by October, 1992, a full three-years of data were available for computer assisted analysis.

During early PY1992, the data from 1991 3-week samples, were captured for all traps. This represented a doubling of trap units of data available for 1991 over 1990 (to 1680). This information has not yet been entered into the database, but will be as time permits.

Four hundred and fifty 1992 samples from the Keating Project on biodiversity of forests in the McDonald Creek drainage are 100% sorted, and 0% counted at this time. The data will be delivered to Mr. Keating by 15 May 1993.

Hand-collected material, 2 ultraviolet light traps, and a flight intercept and Lindgren funnel associated with the McDonald Creek drainage study are maintained to add species inventory data to the GNP data base, but are not quantitatively investigated.

To date, 950 species of beetles, of 78 families, have been identified from Glacier National Park during this study. The rate of discoveries continues to be rapid.

The structure of the data available to date have allowed several interesting preliminary tests. Because the study is designed as a five-year project, no publications have been prepared, but these preliminary analyses do provide glimpses of things to come. The text and tables that follow are taken from a poster presentation: Ivie, M. A., L. L. Ivie, and D. L. Gustafson. **Flight Intercepts and Lindgren Funnels vs. Pitfall Traps as**

**Quantitative Devices for Coleopteran Biodiversity Measurement.** Poster presentation at National Meetings of the Entomological Society of America, Baltimore, 09 December 1992.

NEWS STORIES COVERING IVIE AND IVIE PROJECT IN GLACIER NAT. PARK.

Beetle Research May Help Protect Ecosystem. Northwest Parks and Wildlife, (Florence, OR). December,1992/January,1993 issue, 3(2): 7. [color photograph]

Beetle Clues. Scientists use Beetles to Monitor Ecological Changes. Montana State University Exchange, Bozeman, MT, Summer 1992. p. 2. [photograph]

Beetles may provide clues about biodiversity. Ranger-Review, Glendive, MT. 09 August 1992.

Beetle research may help protect ecosystem. River Press, Fort Benton, MT. 12 August 1992.

Beetle research may help protect ecosystem. Valley Press, Plains, MT. 13 August 1992.

Beetle research may help protect ecosystem. Mineral Independent, Superior, MT. 13 August 1992.

Beetle research may help protect the ecosystem. Glasgow Courier. Glasgow, MT. 13 August 1992.

Researchers at MSU are aided by beetles. Lewistown News-Argus. Lewiston, MT. 16 August 1992.

Beetle research may help protect ecosystem. Ravailli Republic. Hamilton, MT. 20 August 1992.

Indicator species? As beetles go, so goes the forest, scientists say. Daily Inter Lake, Kalispell, MT. 06 September 1992.

Beetles echo the hearthbeat of park. Missoulian, Missoula, MT. 08 September 1992.

MSU pair study Glacier insects. Montana Standard. Butte, MT. 08 September 1992.

MSU couple finds 900 species of Glacier beetles. Livingston Enterprise. Livingston, MT. 8 September 1992.

Researchers focus on insects. Havre Daily News. Havre, MT. 08 September 1992.

Beetle research may help protect ecosystem. Powder River Examiner, Broadus, MT. 10 September 1992.

Beetle research may protect ecosystem. Kalispell Weekly News. Kalispell, MT. 11 September 1992.

Beetle `bio-barometer'. Park bugs used to monitor ecosystem's health. Hungry Horse News, Columbia Falls, MT. 25 June 1992. [photograph]

## PROBLEM

Interest in quantitatively assessing biodiversity has increased dramatically in recent years, but few studies rely on the truly specious groups of arthropods. Further, the models and methods used tend to be those previously available from ecology, and are not quantitatively tested against alternatives for effectiveness in the specific area of biodiversity assessment. Few data are available to those planning a project to objectively assist in choosing sampling methods. A considerable array of trapping methods have been employed by systematists interested in non-quantitative sampling of biodiversity, yet few of them have been tested against the ecological standards in this emerging field.

Management decisions in conservation biology are often addressed in terms of a given habitat's uniqueness in biodiversity, requiring data on what species occur there. Since every field entomologist knows that insect faunal composition changes with the season, traps that repeatedly sample a particular area over time are often used. When specific habitats are being compared, non-baited traps* are needed, to avoid enticing a specimen into a habitat. Lastly, cost of operation and yield are always considerations in choosing a sampling system.

With an unsurpassed diversity of species numbers, size ranges, life histories, trophic representation, and reproductive strategies, the beetles should be at the fore of any biodiversity assessment for a given area. Pitfalls are the most commonly used unbaited trap in quantitative studies of this most diverse of orders. It would therefore be expected that they are the most efficient and cost-effective of the various trap designs available.

A study of the effects of fire on beetle populations in Glacier National Park, Montana, USA, provided the opportunity to compare 2 previously little-used trap types to the "pitfall standard" for quantitative measures of alpha biodiversity. It is hoped these data can be used to plan future efforts.

* For our purposes, light is considered a bait.

## HYPOTHESES AND METHODS

An array of 18 replicated sites, each with 3 trap types was established in 1989 in the Red Bench area on the east side of the North Fork of the Flathead River. Each site is in a forested habitat, evenly representing unburned, lightly burned and hard burned forests. Five pitfall traps, 3 flight intercept traps, and 1 (1989 and 1990) or 2 (1991) Lindgren funnels were placed at each site. The 3 trap types were then evaluated for their effectiveness at sampling beetle biodiversity, and compared against the "pitfall standard".

Trap units were used as the basis of comparison, a trap unit being one trap operating for one week. Sample periods consisted of the first week of a four week cycle, repeated throughout the field season. There were 3 sample periods in 1989, 5 in 1990, and 4 in 1991.

Coleoptera from each trap unit were sorted, identified to morpho-species, and individuals counted. Data presented here is based on all non-staphylinid specimens taken.

Analyses were based upon a contingency table, with the null hypothesis that all trap units were equal. The model predicts an equal likelihood of capture for any given beetle species or specimen for each trap unit, irrespective of trap or habitat type. P and $Chi^2$ values are based upon the observed deviation from this expectation. Data available for analysis include forest type, burn condition, year, period, trap type, trap position, and combinations thereof.

Bootstrap (5,000X) sampling of species addition by addition of trap units (time) was used to evaluate trap-type productivity. Deviation from the bootstrap curve would indicate refutation of the null hypothesis that the faunal universe is consistent over time. Variation among trap-types in this observed curve would indicate sampling of independent faunas that differ in this characteristic.

Combinations of traps were evaluated to find optimal-effort allocations by bootstrapping (1,000X) observed data combinations for 200 trap units, and plotting the results of 2 and 3-way allocations.

**Rankings of the trap-types on criteria of cost, productivity, susceptibility to loss, and overall desirability (1= best).**

Cost

Equipment purchase
1. Pitfall ($2)
2. Flight Intercept ($15)
3. Lindgren Funnel ($65)

Installation Time
1. Lindgren Funnel
2. Flight Intercept
3. Pitfall

Field Personnel Time
1. Lindgren Funnel
2. Flight Intercept
3. Pitfall

Lab Sorting Time/Specimen Retrieved
1. Lindgren Funnel
2. Flight Intercept
3. Pitfall

Disturbance Rates
1. Flight Intercept (2.60%)
1. Lindgren Funnel (4.69%)
1. Pitfall (5.94%)

Productivity (Species in first 200 trap units, bootstrapped 1,000 times)
1. Flight Intercept (188)
1. Lindgren Funnel (180)
3. Pitfall (103)

Productivity (Specimens per Trap Unit)
1. Flight Intercept (14.79)
1. Lindgren Funnel (12.81)
3. Pitfall (3.21)

Species Unique to Trap-Type (excepting singletons)
1. Flight Intercept (46) (55 singletons)
1. Lindgren Funnel (32) (37 singletons)
3. Pitfall (23) (19 singletons)

Overall Cost
1. Lindgren Funnel
2. Flight Intercept
3. Pitfall

**Overall Rating, Costs and Effectiveness**

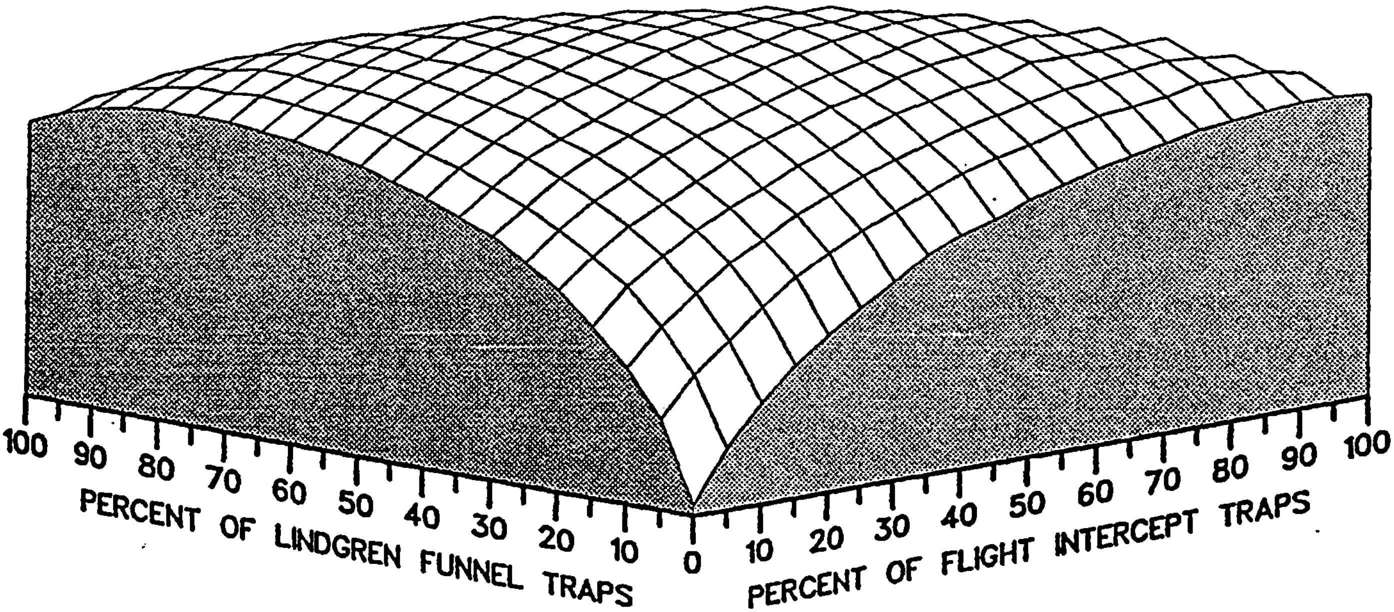
1. Lindgren Funnel
2. Flight Intercept
3. Pitfall

## CONCLUSIONS

The use of pitfall traps as a sole or best method for sampling beetle biodiversity is not supported. Both Lindgren Funnels and Flight Intercept Traps are superior for this purpose, at least in boreal coniferous forests. For cost effectiveness, Lindgren Funnels are the single best method, but an optimal sampling effort would combine Lindgren Funnels and Flight Intercepts. Pitfalls may be incorporated into a combination of various trap methods, which will give a better overall estimate than any one or two trap-types alone. Alternatively, they may be used when targeting specific groups demonstrated to have a trap bias. Before pitfalls are used alone for a specific subgroup in a specific environment, they should be evaluated against other methods to demonstrate trap bias in the subgroup targeted.

In our system, for 200 trap units, the optimal combination is 10% Pitfalls, 45% Lindgren Funnels, and 45% Flight Intercept Traps. As the number of proposed trap units increases, the percentage of Pitfalls should be slightly increased. For an infinite number of trap units, equal proportions are expected to be best, but even ignoring cost factors, Pitfalls should never exceed 33% of the total mix.

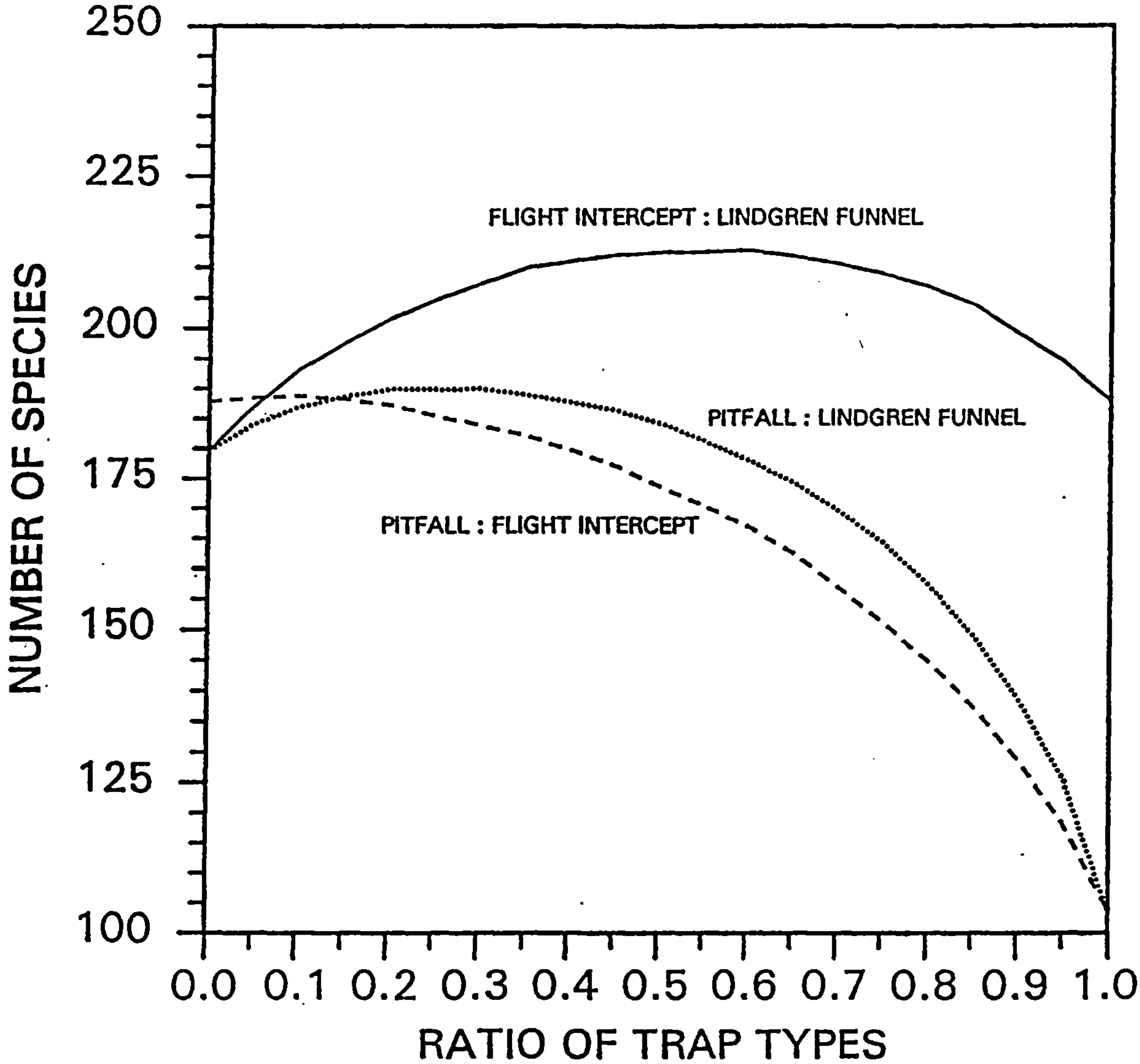
These data give a basis for balancing time, cost, and goals in planning an inventory effort.



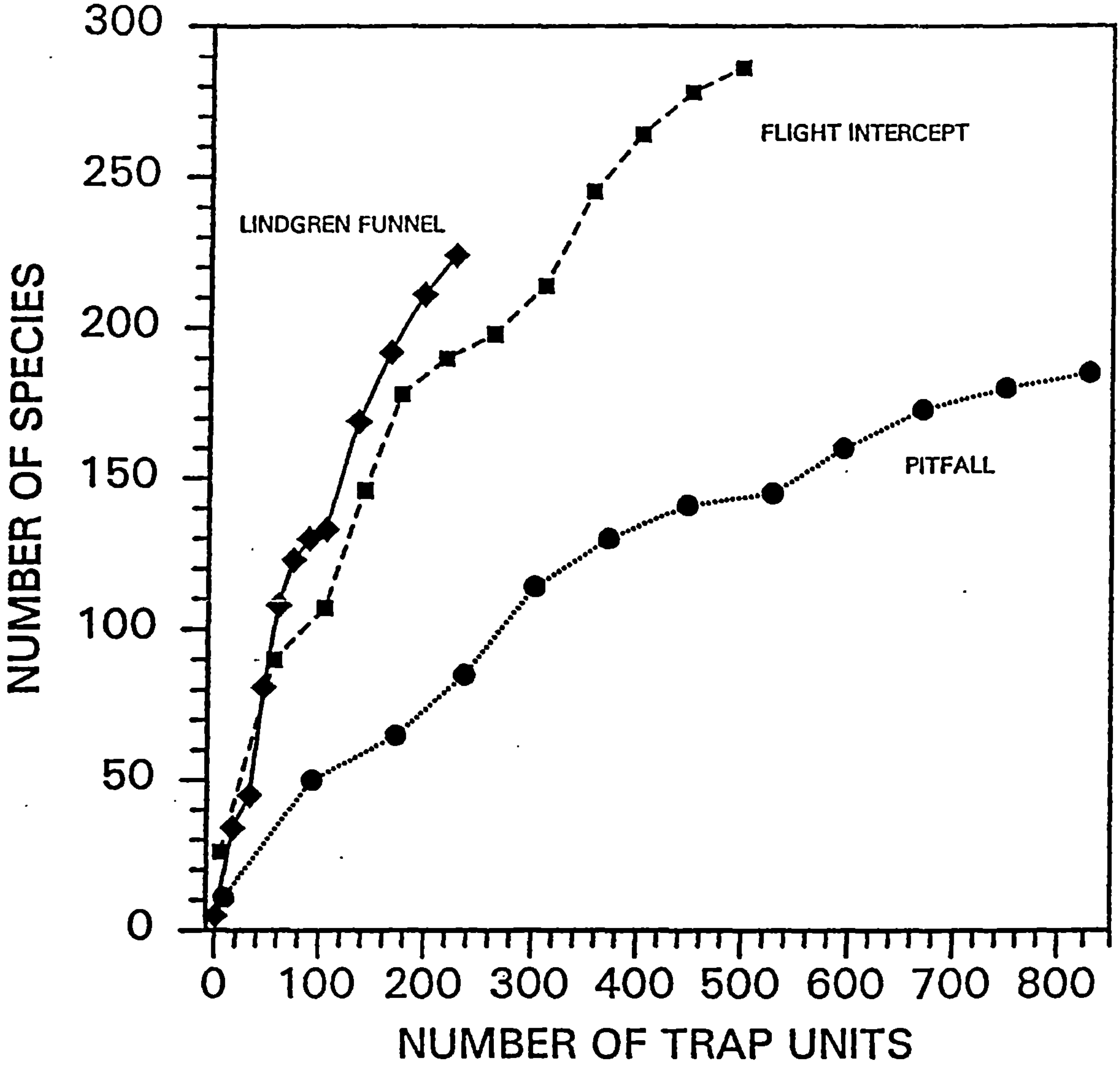

The number of species expected in 200 trap units composed of various numbers of pitfall traps, flight intercept traps and Lindgren funnel traps. Results for each combination are based on 1000 bootstrap samples from the observed results for intact traps in forest stands. The percent of pitfall traps brings the total for each cell to 100%

The number of species expected in 200 trap units composed of various numbers of pitfall traps, flight intercept traps and Lindgren funnel traps. Results for each combination are based on 1000 bootstrap samples from the observed results for intact traps in forest stands. The percent of pitfall traps brings the total for each cell to 100%.

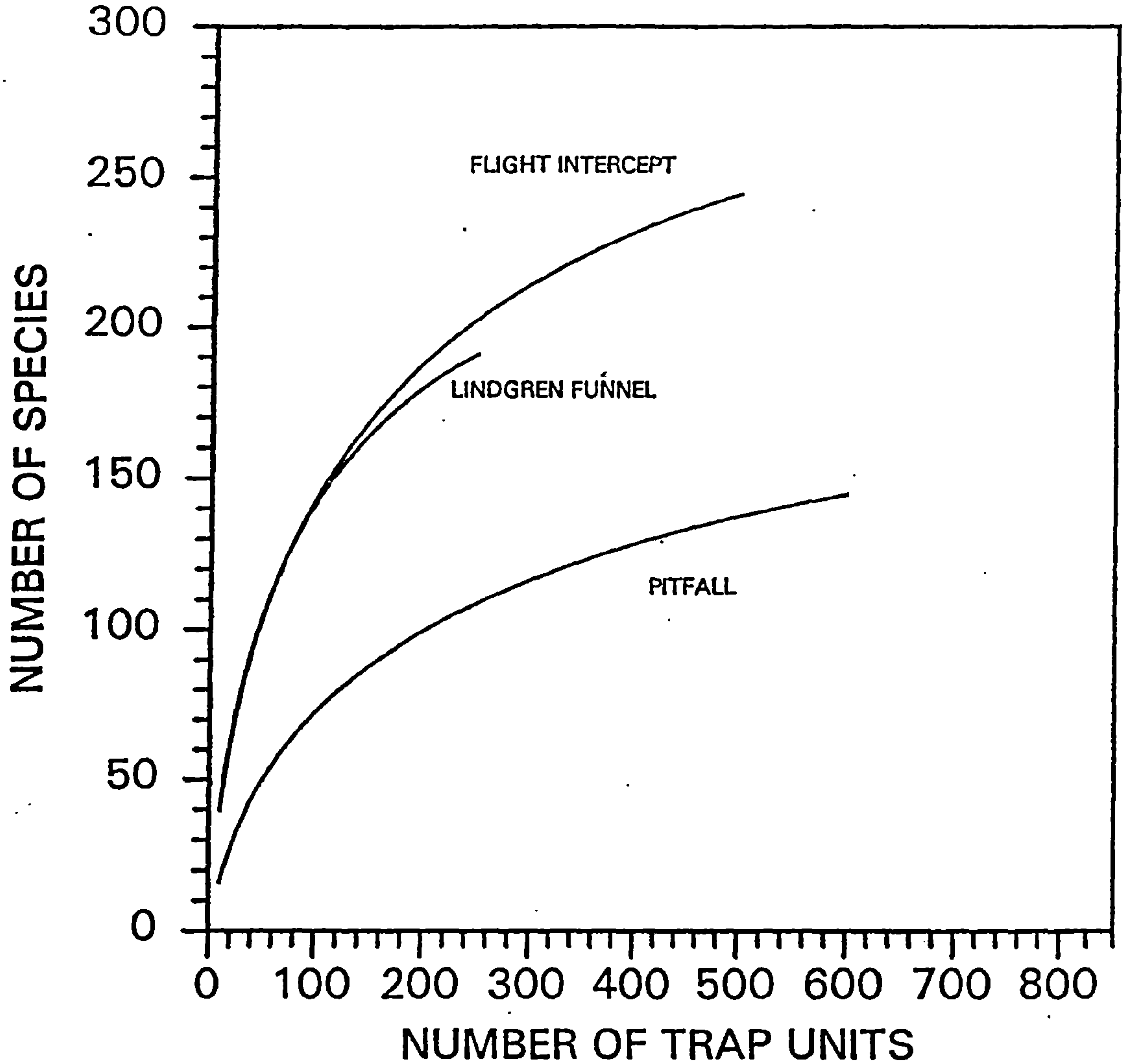
| %FIT \ % LF | 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 188 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 95 | 189 | 194 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 90 | 189 | 196 | 199 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 85 | 188 | 196 | 200 | 204 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 80 | 187 | 196 | 201 | 204 | 207 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 75 | 186 | 194 | 200 | 204 | 207 | 209 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 70 | 184 | 193 | 199 | 204 | 208 | 210 | 211 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 65 | 182 | 192 | 198 | 204 | 207 | 210 | 212 | 212 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 60 | 180 | 190 | 196 | 201 | 206 | 210 | 212 | 213 | 213 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 55 | 177 | 187 | 194 | 200 | 205 | 208 | 211 | 212 | 213 | 213 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 50 | 174 | 185 | 192 | 198 | 203 | 206 | 210 | 212 | 213 | 213 | 212 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 45 | 170 | 182 | 189 | 196 | 200 | 204 | 208 | 210 | 212 | 213 | 213 | 212 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 40 | 167 | 178 | 186 | 193 | 198 | 202 | 206 | 208 | 211 | 212 | 212 | 212 | 211 | --- | --- | --- | --- | --- | --- | --- | --- |
| 35 | 163 | 174 | 183 | 189 | 195 | 199 | 203 | 206 | 209 | 210 | 211 | 211 | 211 | 210 | --- | --- | --- | --- | --- | --- | --- |
| 30 | 157 | 170 | 179 | 186 | 192 | 196 | 201 | 204 | 206 | 208 | 209 | 210 | 210 | 210 | 207 | --- | --- | --- | --- | --- | --- |
| 25 | 151 | 165 | 175 | 181 | 188 | 193 | 197 | 200 | 203 | 205 | 207 | 208 | 209 | 208 | 207 | 205 | --- | --- | --- | --- | --- |
| 20 | 145 | 160 | 169 | 177 | 183 | 189 | 193 | 196 | 200 | 202 | 204 | 205 | 205 | 206 | 205 | 205 | 202 | --- | --- | --- | --- |
| 15 | 138 | 153 | 164 | 172 | 178 | 184 | 189 | 192 | 196 | 198 | 200 | 202 | 203 | 203 | 203 | 203 | 201 | 198 | --- | --- | --- |
| 10 | 129 | 145 | 157 | 166 | 173 | 179 | 184 | 188 | 191 | 194 | 196 | 198 | 199 | 199 | 200 | 200 | 198 | 197 | 193 | --- | --- |
| 5 | 118 | 137 | 149 | 159 | 166 | 172 | 177 | 181 | 185 | 188 | 191 | 193 | 194 | 195 | 196 | 195 | 195 | 193 | 191 | 187 | --- |
| 0 | 103 | 126 | 139 | 149 | 158 | 164 | 170 | 174 | 178 | 181 | 184 | 186 | 188 | 189 | 190 | 190 | 190 | 189 | 187 | 184 | 180 |



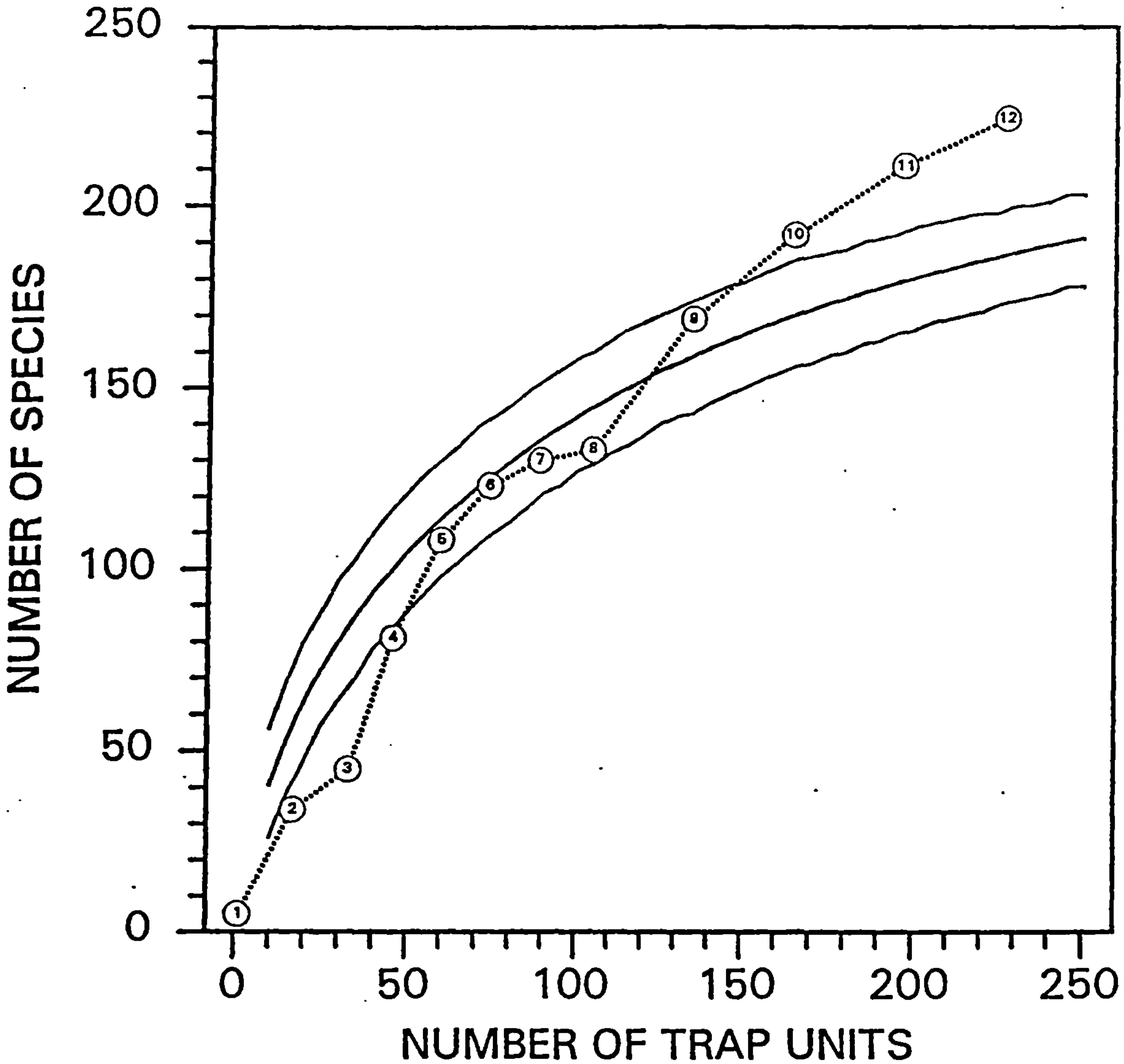

The number of species expected in 200 trap units composed of various numbers of pitfall traps, flight intercept traps and Lindgren funnel traps in two-way combinations. Results for each combination are based on 1000 bootstrap samples from the observed results for intact traps in forest stands.



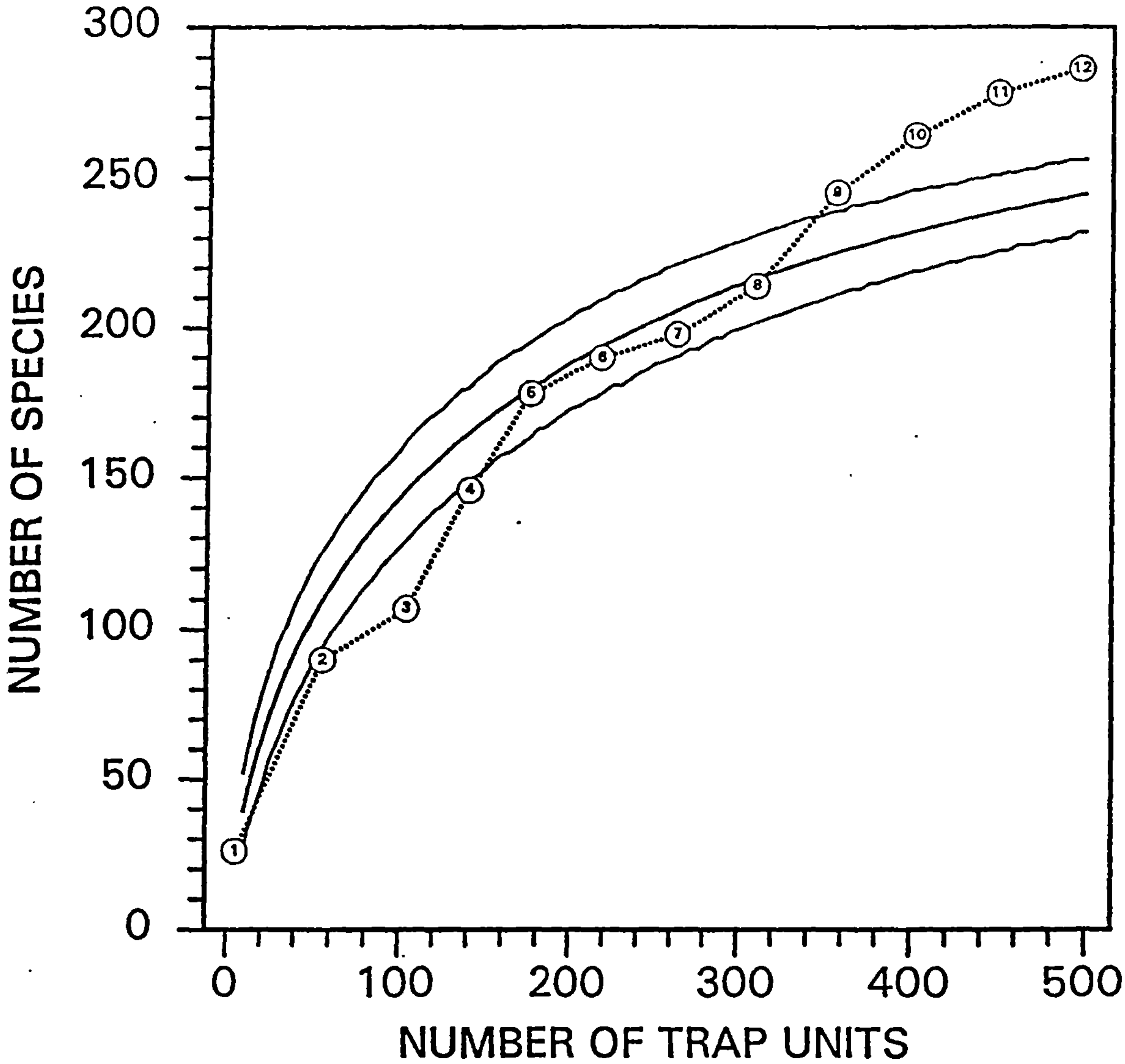

Cumulative number of species taken by the 3 types of traps in forest stands. Sample points represent the cumulative results at the 12 sample periods over the first three years of the study.



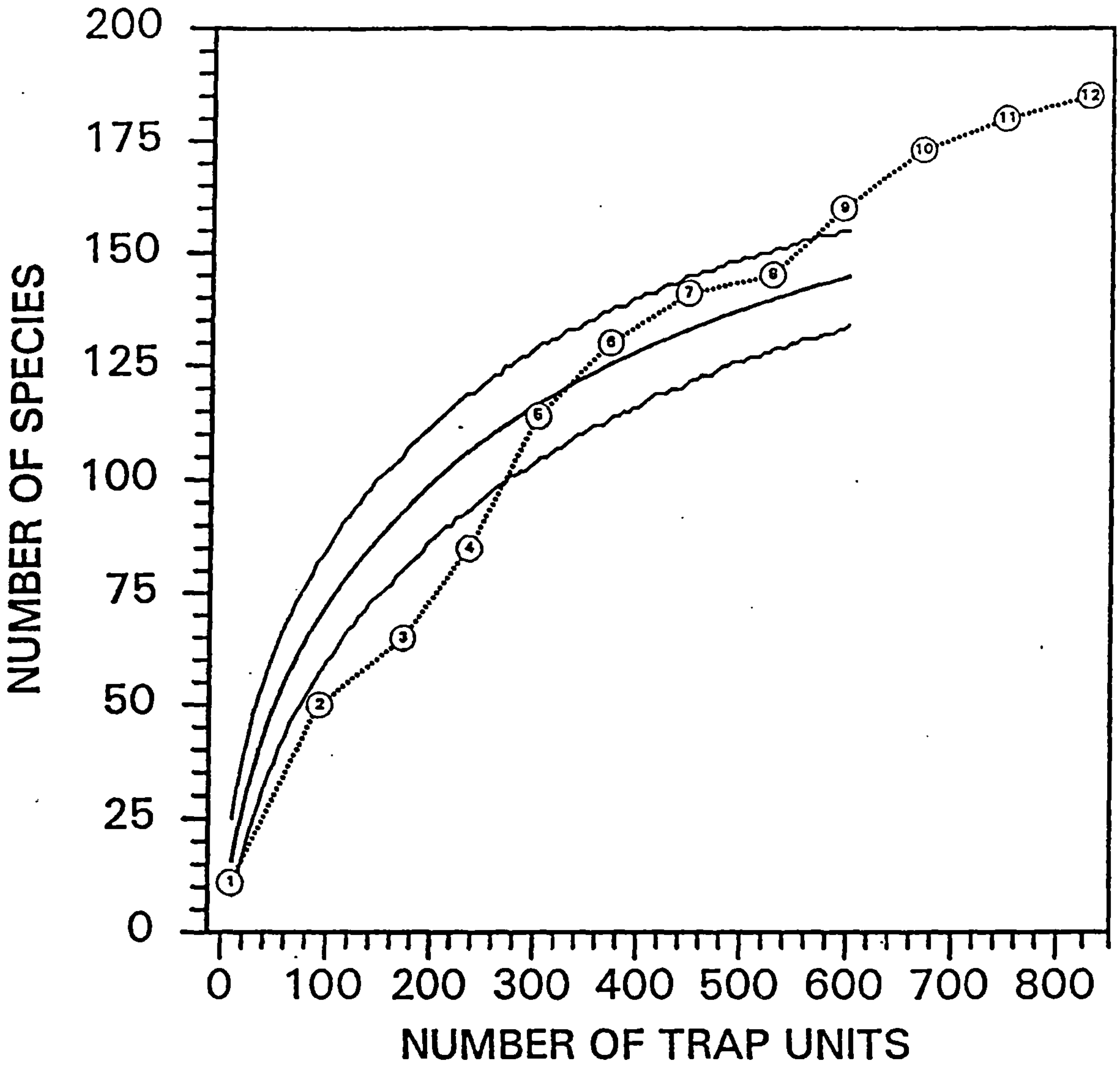

The mean number of species expected in various numbers of the 3 types of traps based on 5000 bootstrap samples of the observed results of intact traps in forest stands, 828 pitfall traps, 497 interception traps and 227 funnel traps.



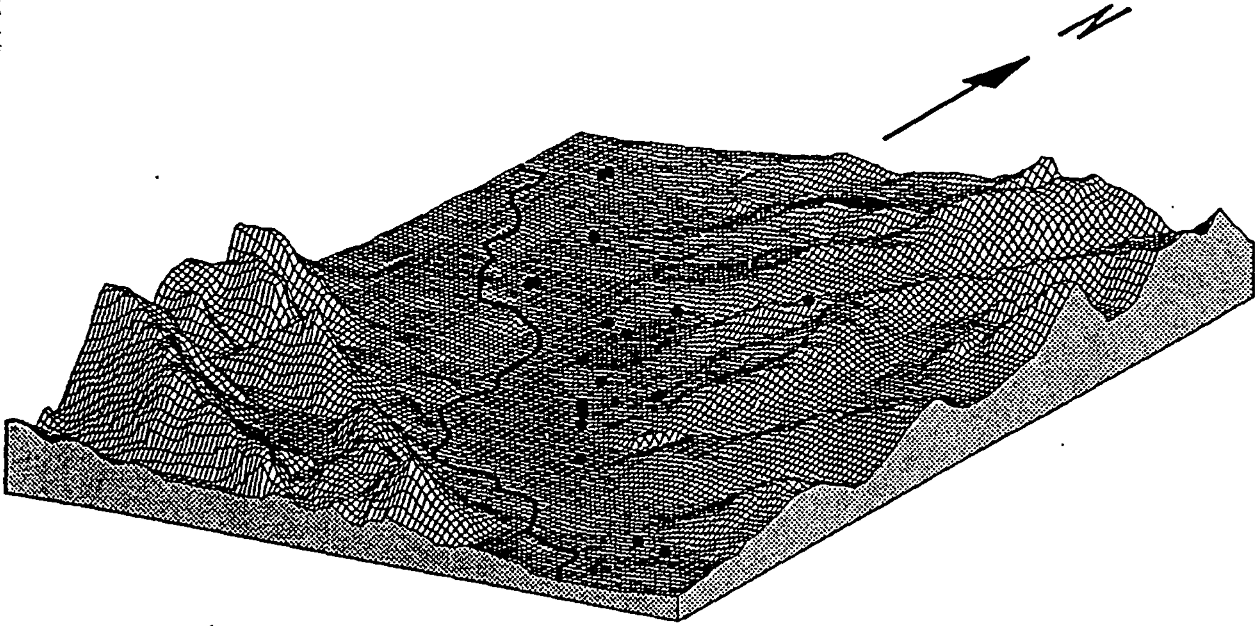

The mean number of species expected in various numbers of Lindgren funnel traps based on 5000 bootstrap samples of the 227 intact traps. The 95% confidence interval is also shown. Sample points represent the cumulative results at the 12 samples periods (1-3 are 1989, 4-8 are 1990 and 9-12 are 1991.




The mean number of species expected in various numbers of flight intercept traps based on 5000 bootstrap samples of the 497 intact traps. The 95% confidence interval is also shown. Sample points represent the cumulative results at the 12 samples periods (1-3 are 1989, 4-8 are 1990 and 9-12 are 1991.




The mean number of species expected in various numbers of pitfall traps based on 5000 bootstrap samples of the 828 intact traps in forest stands. The 95% confidence interval is also shown. Sample points represent the cumulative results at the 12 samples periods (1-3 are 1989, 4-8 are 1990 and 9-12 are 1991.




Digital elevation model representation of the study area showing the trap sites and the Glacier National Park border. The area is 16.9 km east-west by 22.2 km north-south. The spacing of the grid lines is at 6 arc-seconds. The view is from the southeast at a 30° altitude angle and the vertical exaggeration is 3:1.